


Activation of Two Weak IR Fundamentals of Solid Methane: The Importance of Amorphous Ices


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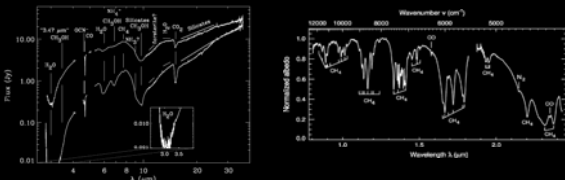
ACS National Meeting, August 18, 2015

The Cosmic Ice Laboratory

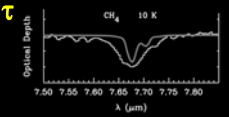


- radiation chemistry
- thermal chemistry
- photochemistry
- reference spectra
- IR band strengths ←
- optical constants
- refractive indices
- ice densities

Molecular Abundances



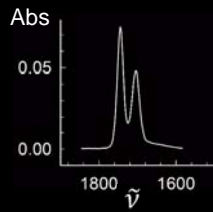
Spitzer Space Telescope



Measure band intensities

BUT still need lab spectra for comparison.

Want to convert band area into # ice molecules



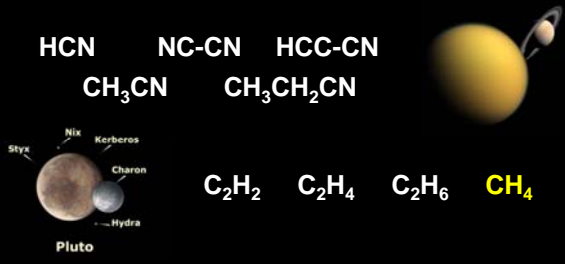
n and k
(optical constants)

$$A' = \frac{\ln(10) \int_{\text{band}} (\text{Abs}) d\tilde{\nu}}{\text{thickness} \times \text{no. density}}$$

And then apply N , column density = $\frac{\int \tau d\tilde{\nu}}{A'}$

Optical Constants and Band Strengths of Ices - v. 4

HCN NC-CN HCC-CN
CH₃CN CH₃CH₂CN



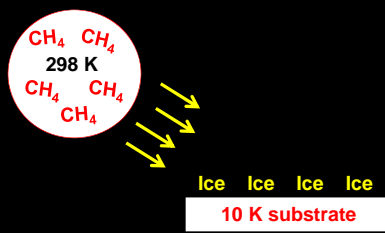
C₂H₂ C₂H₄ C₂H₆ **CH₄**

Hudson et al., Icarus, 2014a and 2014b
Moore, Hudson et al., ApJS, 2010

Hudson, Gerakines, & Loeffler, PCCP, 2015
Gerakines & Hudson, ApJL, 2015

The Phase Problem

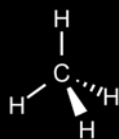
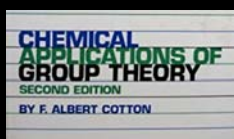
amorphous ice	crystalline ice
low T	warming or high T
slow formation	fast formation



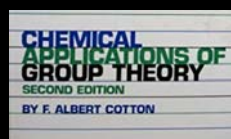
CH₄ CH₄
298 K
CH₄ CH₄
CH₄

Ice Ice Ice Ice
10 K substrate

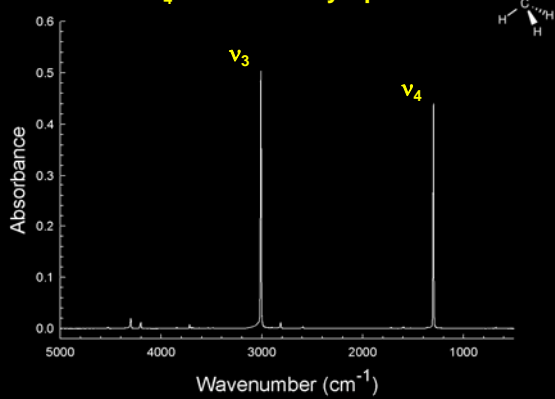
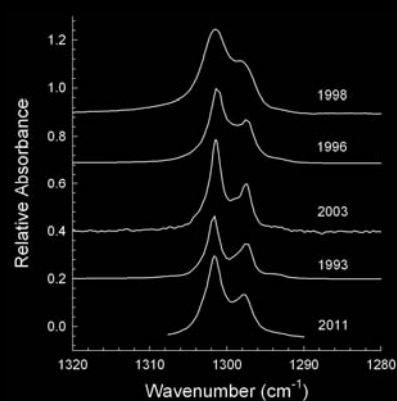
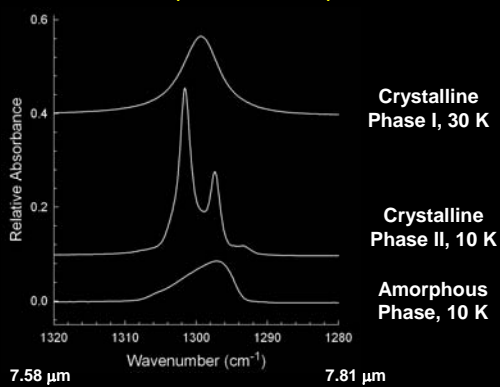
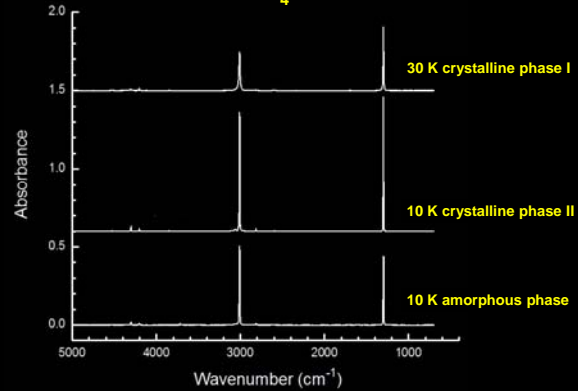
IR Selection Rules Vary

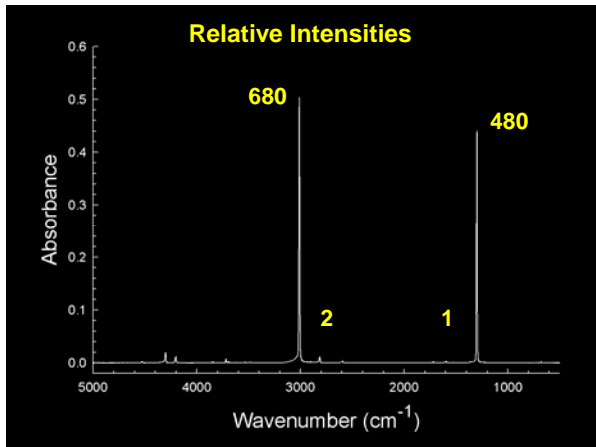
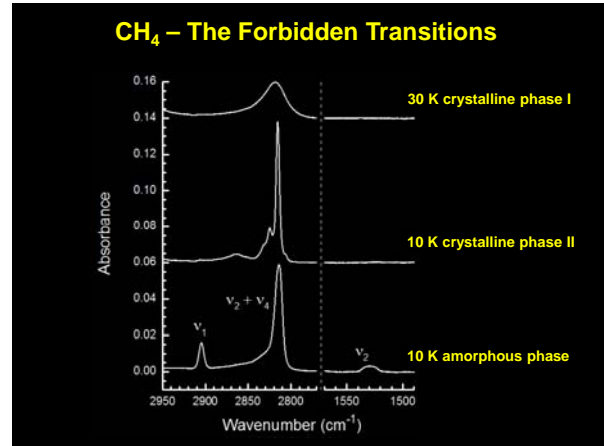
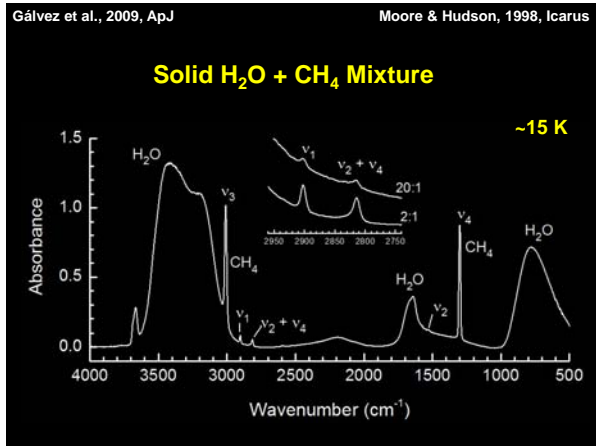
gas phase
matrix isolatedcrystalline
phaseamorphous phase
liquid phase

IR Selection Rules Vary

gas phase
matrix isolatedcrystalline
phaseamorphous phase
liquid phase

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Solid CH₄ – 10 K Survey Spectrum10 K CH₄ from Five Labsν₄ Band of CH₄Solid CH₄ – Mid IR



A chemistry check

Isoelectronic Species

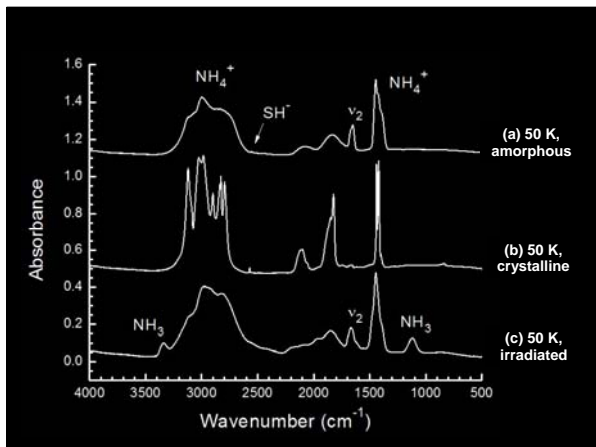
CH₄ NH₄⁺

NH₄SH and Jupiter 

$$\text{NH}_3 + \text{H}_2\text{S} \rightarrow \text{NH}_4^+ + \text{HS}^-$$

amorphous $\xrightarrow{\Delta}$ crystallize $\xrightarrow{\text{rad}}$ amorphous


v₂ v₂



Why Study Amorphous Ices?

- Found in Solar System and interstellar medium
- Irradiated solids are amorphous
- First approx. for icy mixtures (> 1 component)
- “Fallback” data for band strengths and spectra

- Provides confidence in understanding of ices
- Band strengths to compare to calculations
- Terrestrial applications – forbidden transitions



"Mmm ...
forbidden
transition"

Acknowledgments

Co-Workers

Perry Gerakines Mark Loeffler Marla Moore Robert Ferrante

NASA \$\$ Programs

CDAP OPR APRA NASA Astrobiology Institute

<http://science.gsfc.nasa.gov/691/cosmicice/>



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